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INTRODUCTION OF PEAK-LOAD PRICING IN EUROPE,

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Derek J. McKay

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## PREFACE

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SUMMARY

Some form of peak-load pricing has been practiced in Britain and France for the last several decades. While the greatest gains in terms of cost saving have taken place at the industrial level, both countries have found it profitable to extend some form of time-of-day tariff to the residential consumer. The major loads which have been modulated in response to these price signals are those associated with storage heating. The storage devices are generally automatically switched on when the cheaper electricity is available. A recurrent problem which has prompted evolution of the British tariffs has been the starting load when large numbers of thermostatically controlled loads are initially switched on. Staggered time periods are used in the newer tariffs to alleviate this problem and avoid artificial system peaks. The French do not seem to be bothered by this problem at present.

## I INTRODUCTION

The purpose of this paper is to present a brief historical review of certain aspects of the European experience with peak-load pricing. This varied and informative experience has been rather fully presented in the recent book by Mitchell, Manning and Acton [1] and it is not possible in the space available to treat the subject as fully here. This author's major experience has been with the French and British tariff structures so this paper will limit itself to the aspects of these systems that appear relevant to thermal-energy storage and in particular the tariffs facing the residential consumer. By concentrating almost exclusively on Britain and France we can trace in more detail the evolution of some important ideas than would have been possible had a Grand Tour been attempted.

While we will treat France and Britain in separate sections it is worthwhile initially examining the general circumstances that the electric utility industries found themselves in during the years immediately after the Second World War. In both countries almost no new generating capacity had been added in the war years. This placed considerable pressure on existing capacity. In both countries the governments had concluded sweeping reorganization of the industry. At almost the same time (1949-51) in both countries, theoretical economic articles on tariff reform were published independently [2] [3].

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[1] A significant portion of this paper has been drawn directly from Mitchell, Manning and Acton (1978)(see Bibliography).

[2] Houthakker, H.S. 1951, "Electricity Tariffs in Theory and Practice." Economic Journal 61(March):1-25.

[3] Boiteux, Marcel. 1949 "La Tarification des Demandes en Pointe." Revue Generale de l'Electricite 58:321-40.

The concepts proposed in these papers were implemented first in France, with the introduction of the Tarif Vert as an option for high voltage customers. The British introduced peak-load tariffs several years later but these were initially based on average cost principles rather than the marginal cost ideas used by the French. Marginal costs were eventually used (at least as a starting point) in Britain and the differences observable in the tariffs today are largely the result of significantly different cost structures in the two countries as well as those caused by the differences in industry organization.

These high voltage tariffs were naturally first made available to industrial consumers and it was a considerable time later before residential and commercial customers could avail themselves of peak-load prices. The low voltage peak-period prices were almost exclusively aimed at those customers with water and space heating loads where storage devices enabled a profitable shifting of load to the hours of cheaper electricity.

In contrast to the relative experience of France and Britain with high voltage tariffs, Britain was able, for largely institutional reasons, to offer residential peak-load tariffs before France. These tariffs have evolved considerably since their initial introduction as circumstances and technology changed. Unlike the experience in some other countries, the concept of load management has invariably been linked with tariff policy in both Britain and France and these residential peak-load tariffs generally offer either as an option or a requirement that certain appliances be controlled or restricted to the

off-peak periods of the tariff.

The following sections will look in more detail at the French and British experience.



## II PEAK-LOAD PRICING IN ENGLAND AND WALES

Britain was drastically short of generating capacity in the immediate postwar years and on occasion suffered as much as a 30 percent excess demand[1]. A vigorous construction program ensued and the Electricity Act of 1947 dramatically reorganized the industry. The industry was reorganized again in 1957 and for simplicity we will describe the resulting structure after that date, though from a tariff point of view no great misunderstanding will occur if this structure is assumed to exist from 1947.

### Industry Organization

There are twelve Area Boards which purchase electricity from the Central Electricity Generating Board and distribute it to customers in their regions. The Area Boards purchase power under the terms of the Bulk Supply Tariff and have considerable freedom on the nature of tariffs that they offer to their customers. The actions of the Area Boards are governed by a number of statutory requirements concerning financing and non discriminatory pricing practices. The overall coordination of the industry is the responsibility of the Electricity Council which reports to the Secretary of State for Energy. The Generating Board has some additional responsibilities as a nationalized industry[2].

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[1] During these generation shortfalls the supply authorities became expert in the techniques of voltage and frequency reduction coupled with routine rolling blackouts.

[2] An additional reorganization of the industry appeared imminent in 1978. However since the change of government, it is not clear what direction, if any, such a reorganization may take.

### The Bulk Supply Tariff

In recent years the Bulk Supply Tariff(BST) has been revised annually in both level and structure as illustrated in Table 1. As noted previously the early objective of the tariff was to help reduce peak demand on very scarce capacity resources. In later years after a vigorous construction program this was no longer important and the concern became on how to best utilize the capacity. To this end many tariffs were offered which encouraged additional off peak uses and hence more economic operation of the power plants.

It is a complex tariff with many subtle features not all of which will be explained here. The price per kilowatt-hour varies according to the time of day, with an off-peak rate in effect from midnight to 0800, a shoulder rate that applies at most other hours, and a peak energy rate that takes effect during the two half-hours of the actual system peak (retrospectively determined). Capacity charges are levied according to a complex formula that reflects demand at the time both of the generating system's peak and of the Area Board's own peak demand. Area Boards pay a "basic" demand charge, which is a rate per kilowatt of the Area Board's average demand during periods when the system is between 85 and 86 percent of its peak demand. The system peak demand is defined as an average of the three system peaks separated by at least ten days. A peaking capacity charge(or rebate if it is negative) is levied on the difference between the Area Board's basic demand and the average demand during the system peak demand. In addition there is an interruptible provision and until this year there was very low night energy charge which had the feature of appearing as a negative marginal price. There

Table 1

THE EVOLUTION OF THE BULK SUPPLY TARIFF FROM  
AVERAGE TO MARGINAL COST PRICING [a]

Year	Demand Charges (pounds/kw)			Unit Charges[b] (pence/kwh)			Fuel Adjust. (pence/kwh)[c]
1948-49	3.50			0.20			0.06
1961-62	7.35			0.27			0.08
				<u>Day</u>	<u>Night</u>		
1962-63	8.00			0.26	0.22		0.02
1966-67	9.00			0.29	0.24		0.04
	<u>Peak</u>	<u>Basic</u>		<u>Peak</u>	<u>Day</u>	<u>Night</u>	
1967-68	4.00	11.16		0.47	0.30	0.24	0.05
1970-71	4.00	11.30		0.51	0.34	0.29	0.09
1974-75	4.27	17.87		0.90	0.73	0.67	0.46
	<u>Service</u>						
1975-76	8.00	15.24	0.60	1.74	0.99	0.72	0.14
1976-77	8.00	20.55	0.70	2.07	1.11	0.77	0.14
	<u>Peak &amp; LMW</u>						
1977-78	10.00	25.00	0.75	2.52	1.28	0.80	0.16[d]

[a] This table was extracted from A.J. Graham(1978) except where noted.

[b] The fuel cost adjustment is included in the unit charges shown.

[c] ((Average fuel cost in year)-(fuel base cost))\*(fuel cost adjustment)

[d] An average of approximations by Graham(1978) and by Freeman of McLellan and Partners, Consulting Engineers, Surrey(private correspondence)

is no explicit seasonal component to the rates, but the "basic" demand charge effectively defines a period of the year when the probability of incurring the demand charge is greatest. This period is invariably the winter daytime.

The features of the Bulk Supply Tariff are much more important when considering the way Area Boards formulate their industrial tariffs than when considering residential tariffs. Large industrial customers are very familiar with the terms of the BST and consequently are in a

position to negotiate tariffs that can save both the Area Board and the customer money. Often an Area Board will offer features of the BST directly to large customers, particularly if it results in lower financial risk to the Board. At the residential level there is no such possibility of any individual customer being able to alter the Board's load and consequently the tariffs offered to these customers are much simpler and based on the expected load of the whole class of customer. It is of interest to note however, that the Area Boards will tend to behave as if they actually purchased power from a generating system with the cost characteristics defined by the BST when they set the residential tariffs.

#### Residential Peak-Load Pricing

In 1961[1] the Area Boards of England and Wales began an active campaign to promote the residential use of storage units for space heating. Radiators were supplied and metered on a separate circuit that was switched on by a clock control during hours of low system loads. These early storage units required a three hour afternoon boost which was beginning to cause problems by the late sixties. In 1969 a new tariff called the white meter tariff was introduced by all Area Boards which offered only an eight hour off-peak period. The previous restricted hour tariff with the afternoon boost was not available to new customers after 1970. Very recently a new tariff called the economy seven has been introduced which gives the Boards more freedom in

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[1] The Eastern Area Board actually offered a tariff with a small night day differential in 1952 for those willing to pay the additional metering cost.

avoiding storage switch-on induced peaks.

In recent years the competitive advantage that electricity used to enjoy relative to gas and coal as a heating fuel has been eroded by the price of natural gas from the North Sea. This has caused the Area Boards to closely examine the nature of their off-peak tariffs to ensure that they are as attractive as possible within the cost constraints.

### III PEAK-LOAD PRICING IN FRANCE

Immediately before nationalization there were about 1200 independent suppliers of electricity in France. The tariffs they had offered were often very inconsistent for similar customers in geographically adjacent locations. Tariff reform thus became an immediate and pressing task for the new organization (Electricite de France).

By 1955 EdF had developed marginal cost schedules, and in 1958 the Green Tariff (Tarif Vert) was offered on an optional basis to high-voltage customers. After five years 88 percent of the eligible customers had selected it and by 1968 it was no longer optional, but the standard tariff. During this period uniform tariff increases took place but maintained the original ratios between prices charged in different periods and between different voltage levels. A tariff review was performed in 1971-73 which left the form and structure unchanged but based the levels on the new computations of marginal costs.

#### The Green Tariff

The Green Tariff is so named because of the colour of the original report. There are five time periods in which prices vary: winter peak, winter shoulder, winter off-peak, summer shoulder and summer off-peak. The energy prices are different in each period. In addition there is a subscribed demand charge which is based on a concept called reduced power. The consumer subscribes to a level of maximum demand in each of the above periods. There is a restriction that forces the consumer to

have at least as much subscribed in off peak periods as in the peak period. However the subscription charge on the off peak periods is only assessed on the demand subscribed in excess of that in the higher priced period[1] The amount subscribed in each period are combined in the following manner to arrive at the reduced power.

$$R.P. = P1 + W1*(P2 - P1) + W2*(P3 - P2) + W3*(P4 - P3) + W4*(P5 - P4)$$

Thus a single charge on reduced power is transformable into five different demand charges. Within the above structure there are five different price schedules among which the customer can choose. These have different weightings of the demand and energy charges and are so structured that it is in the consumer's own interest to select the correct tariff. These tariffs are tailored for customers with load factors[2] of over 5500 hours, between 3500 and 5500 hours, 800 to 3500 hours and less than 800 hours. There is one additional option designed for standby rates for emergency purposes which may be combined with some of the other tariffs. The Green Tariff contracts are for a 5 year term, and the subscribed power levels apply for the duration of the contract. A customer's subscribed level may be increased at any time, in which case the new levels are binding for 5 years. If, in a given month, actual demand exceeds the subscribed level, the excess is billed at the rate of 70 percent of the annual charge per subscribed kilowatt. If the customer exceeds subscribed levels by a substantial margin, EdF will

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[1] The five periods of the year are ordered so as to reflect the scarcity of generating capacity expected and the demand charge is higher in the periods when more scarcity is expected.

[2] In Europe, load factors are often measured in hours of utilization. To convert to the ratio more commonly used in the U.S. it is only necessary to divide by 8760

automatically increase the subscribed levels in the contract, thereby penalizing the customer for future years. In addition EdF maintains the right to install circuit breakers to limit actual demand to no more than 10 percent more than the subscribed level.

Unlike the Bulk Supply Tariff in England and Wales, which is an wholesale tariff under which distributors buy electricity for resale to residential customers, the Green Tariff plays no direct role in residential rates. However, EdF does claim to use the hypothetical situation where the Green Tariff is used as a wholesale rate in forming the Universal Tariff.

#### The Universal Tariff

The reform of the lower voltage tariffs in France was a much more difficult task than that associated with formulation and introduction of the Green Tariff. The fact that only about 115000 customers are on the Green Tariff compared with a potential 20 million for a revised low voltage tariff is one reason. In addition there were numerous legal constraints on the relationship of any new tariff to the old one in terms of price level. This necessitated careful design and numerous compromises. After 5 years of work the Universal Tariff was introduced on an optional basis in 1965.

The previous tariff structure can only be described as confusing. Different uses were billed at different energy rates involving a multiplicity of meters and circuit breakers. The new tariff sought in general to employ a single rate per kilowatt-hour but to differentiate



the demand component according to use (and hence statistical diversity). This was done by extending the notion of subscribed demand enforced by a circuit-breaker. Circuit-breaker capacities can be subscribed at various fixed levels and a statistical relationship between this level and the expected uses is used to compute the charge. This does violate some of the objectives of presenting the consumer with individually correct incentives, but the simplification seems to be more than worthwhile. For all except the largest levels of subscribed demand the subscribed level is recovered largely through a declining block structure where the blocks are determined by the subscribed demand.

In addition to the standard tariff there is an option offered to the Universal Tariff called the "double tariff" which is an off peak tariff similar to some of the British residential tariffs. This allows cheaper energy charges between the hours of 2200 and 0600 but involves an increased fixed charge to cover the additional costs of a day/night meter. About 18 percent of all customers on the Universal Tariff have found it advantageous to take this option, and as expected these are principally those with both storage space-heaters and water-heaters.

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